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OPERATIONS CONCEPTS
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GODDARD SPACE FLIGHT CENTER
GREENBELT, MARYLAND

STDN

OPERATIONS CONCEPTS

1994

Revision 3

September 1988

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CHANGE INFORMATION

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PREFACE

This document defines the Spaceflight Tracking and Data Network (STDN) operations concepts for providing tracking and data acquisition services to an approved user community for the 1994 time period. The operations concepts presented in this document are intentionally held at a high level, and are intended for use by personnel who are familiar with National Aeronautics and Space Administration (NASA) programs.

The operations concepts are based on given network architectures, inherent capabilities and limitations, and the culture of users and networks developed over a 20-year period. Policy and experience have been used in developing or explaining the operations concepts. Lower-level documentation will be developed to clarify and serve as the basis for engineering requirements.

By executive order, the Tracking and Data Relay Satellite System (TDRSS) is designated a national resource and must receive a certain level of protection via security measures applicable to national resources. In addition, NASA has implemented security measures as necessary to support classified missions (refer to the TDRSS Security Classification Guides and the Space Transportation System [STS] Security Classification Guide). The operations concepts reflect the requirements and limitations imposed by security.

This document will be changed by complete revision only.

All comments, suggestions, or questions regarding this document should be directed to:

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DCN CONTROL SHEET

Use this control sheet to record the DCN changes to this document.

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SECTION 1. INTRODUCTION

1.1 BACKGROUND

1.1.1 The Goddard Space Flight Center (GSFC) Spaceflight Tracking and Data Network (STDN) is viewed as an institutional capability to provide Tracking and Data Acquisition (T&DA) services to approved space flight missions. The mission of the STDN is to provide service to the user community. This view is key to providing responsive quality support to users.

1.1.2 The institutional perspective of STDN allows for realistic engineering life-cycle management of STDN systems. This ensures high quality systems in support of yet-to-be-defined future users. Standardized services allow for economical STDN utilization in support of multiple diverse users. Upward compatibility will be maintained for the life of approved missions.

1.1.3 STDN systems have historically undergone gradual change. These changes have occurred as a result of advances in sophisticated spacecraft instrumentation, more complex mission goals, and higher data rates that drive the need to upgrade network systems with state-of-the-art equipment. The operations concepts must evolve continuously to capitalize on lessons learned and preserve a sounding board against which to compare new concepts and ideas. Emphasis on minimizing impacts to the Network Control Center (NCC) is a primary concern. Continuity of operational experience has led to a history of successful accomplishment by the STDN.

1.2 PURPOSE

1.2.1 GENERAL

1.2.1.1 The principal objective of this document is to describe the concept under which the STDN facilities will be operated to provide user support in the 1994 time frame, with emphasis on the NCC. It focuses on the operational posture in 1994, prior to the Space Station, when the Second TDRSS Ground Terminal (STGT) and the retrofitted White Sands Ground Terminal (WSGT) are capable of providing user support with four operational Tracking and Data Relay Satellites (TDRS) (refer to Appendix A). The combination of WSGT and STGT will be referred to as the White Sands Complex (WSC). It is anticipated that the Space Station will conform to 1994 capabilities and interface with the NCC for scheduling and control; unique Space Station requirements will be evaluated as requirements are articulated.

1.2.1.2 The NCC is responsible for operational management control of the STDN, and is the point of contact between users and the STDN. Figure 1-1 depicts the NCC in the 1994 STDN environment.

1.2.1.3 Elements external to the STDN such as NASA Communications Network (Nascom), Flight Dynamics Facility (FDF), Project Operations Control Centers (POCC), Sensor Data Processing Facility (SDPF), and NASA Logistics Support Depot (LSD) are referenced when needed to clarify the STDN operations concepts.

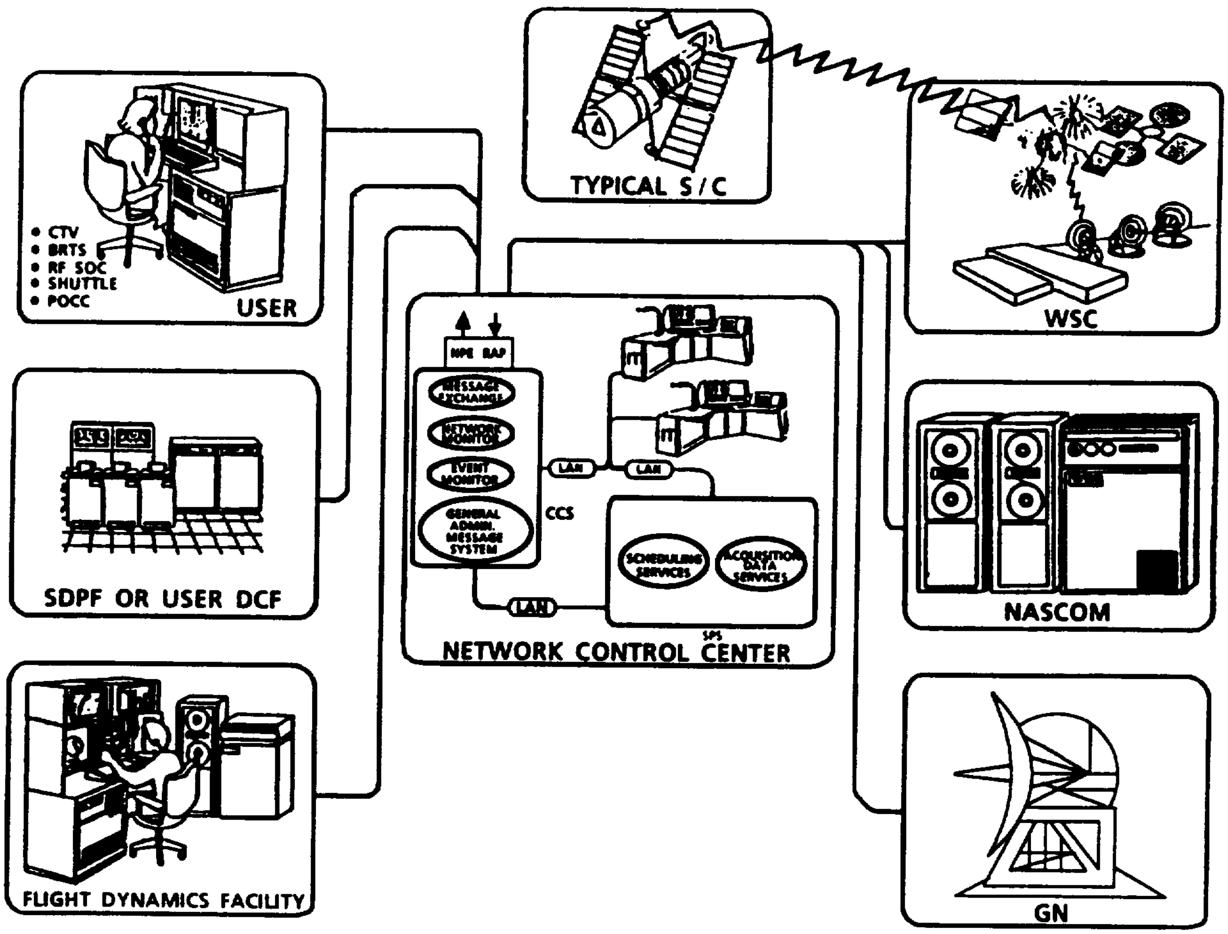

Figure 1-1. NCC in the 1994 STDN Environment

1.2.1.4 User scientific data is transmitted from network facilities to the Information Processing Division (IPD) SDPF. The IPD/STDN interface is primarily for problem reporting, data accountability, and tape recorder playbacks to ensure completeness and validity of data delivered to the scientific community.

1.2.2 ROLE OF THE STDN

1.2.2.1 The primary role of the STDN is to provide T&DA services, including Shuttle-unique support (e.g., air-to-ground voice, television), to a wide variety of earth-orbiting missions from launch through mission completion.

1.2.2.2 The STDN will endeavor to support assigned users' requirements, as expressed in user project Support Instrumentation Requirements Document (SIRD)/ Program Requirements Document (PRD) and responded to in the NASA Support Plan (NSP).

1.2.2.3 In addition, the STDN provides potential and existing users with resource planning services to enable productive and economical use of STDN capabilities.

1.2.3 LEAD CENTER RESPONSIBILITIES

1.2.3.1 Within NASA, the term Lead Center implies a management responsibility for intercenter/agency activities. GSFC is designated as the Lead Center for communications and T&DA support of specific misisons, such as the Space Transportation System (STS).

1.2.3.2 The NCC is responsible for executing real-time mission operations and data system Lead Center obligations, and for coordinating support from other organizations supporting these missions (see Figure 1-2). These include the Deep Space Network (DSN), Eastern Space and Missile Center (ESMC), Western Space and Missile Center (WSMC), Air Force Satellite Control Network (AFSCN), and other NASA resources such as Wallops Flight Facility (WFF) and Dryden Flight Research Facility (DFRF).

1.2.3.3 The STDN occasionally works with tracking stations of the National Oceanic and Atmospheric Administration (NOAA) and cooperating international agencies such as the Japanese National Space Development Agency (NASDA), French Centre National d'Etudes Spatiales (CNES), and European Space Agency (ESA).

1.2.4 OTHER SUPPORTING NETWORKS

The NCC is responsible for maintaining authorized operational interfaces with other networks. The following elements are shown because of their unique support to augment the STDN:

a. <u>26-meter Subnet</u>. The 26-meter subnet comprises Canberra (CAN), Goldstone (GDS), and Madrid (RID). These stations are under the management control of the Jet Propulsion Laboratory (JPL), and are used to support a standard mission set and provide emergency support in the event of user contingency or degraded STDN support.

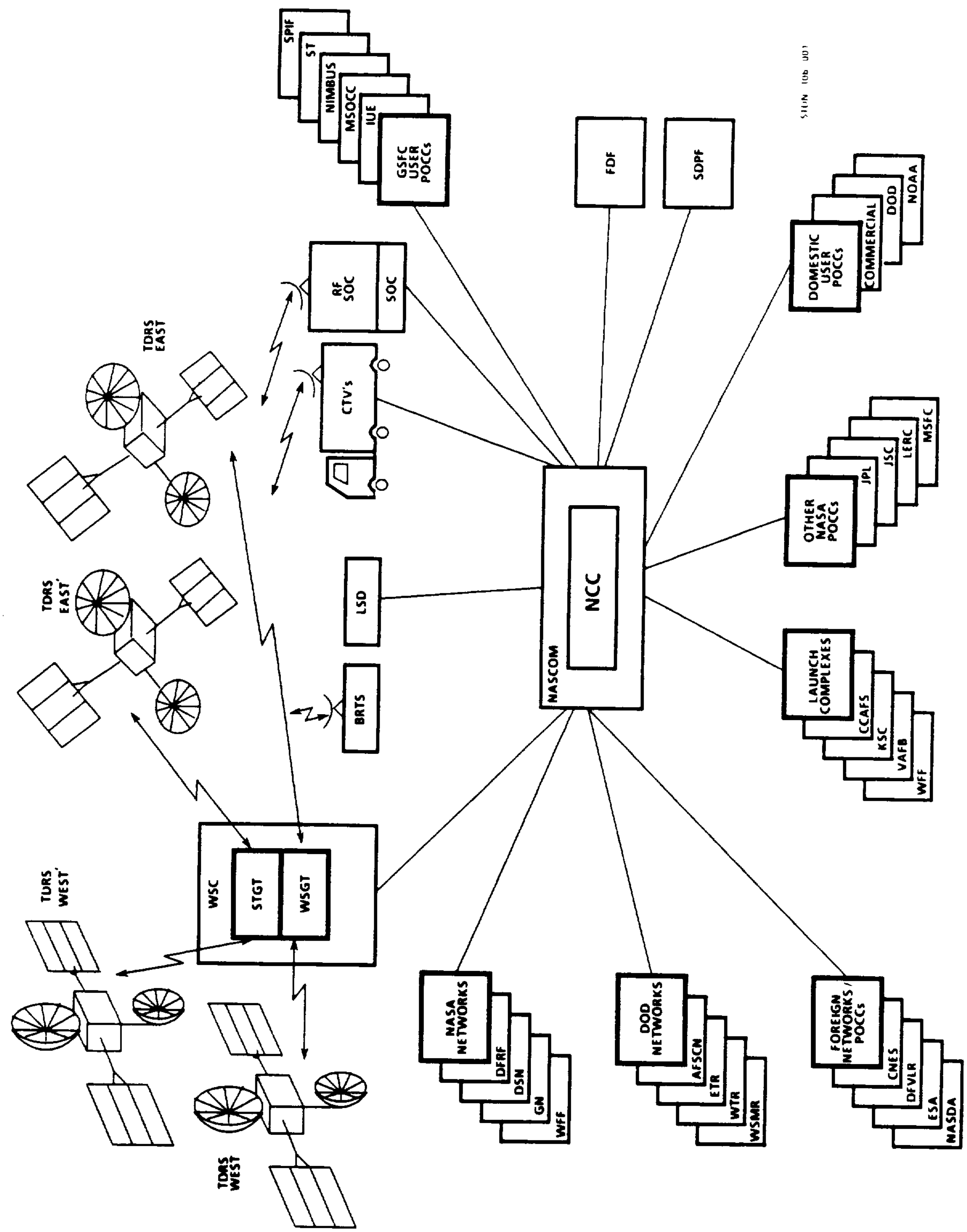

Figure 1-2. GSFC Lead Center Role: 1994

b. DOD Stations. The Department of Defense (DOD) stations are used to provide C-band and S-band support for the STS, and other special mission support.

c. Wallops Flight Facility. This NASA station provides daily on-orbit support to select users. It also provides C-band and range safety support for STS and assigned Expendable Launch Vehicle (ELV) missions.

d. Dryden Flight Research Facility. This NASA station provides S-band telemetry and command and air-to-ground voice support for STS landings at Edwards Air Force Base.

1.3 SCOPE

1.3.1 This revision emphasizes NCC functions; however, the next revision will consider the Space Network (SN), Ground Network (GN), and NCC equally and within a cohesive structure.

1.3.2 Concepts are based on the following assumptions:

a. For the purpose of this operations concept document, the SN consists of the STGT and WSGT ground terminals at White Sands, TDRSS relays, Bilateration Ranging Transponder System (BRTS), and a maximum of four operational TDRS's.

b. STGT will have separate Multiple Access (MA) service capability, as well as Single Access (SA) service capability.

c. Both WSGT and STGT will include Shuttle-unique equipment and a TDRS telemetry/command interface capability with the GN.

d. During WSGT retrofit, the TDRS Launch and Deployment Control Center (TLDCC) will remain operational and have an S-band standalone Tracking, Telemetry, and Command (TT&C) capability.

e. The need for a ground-based network for contingency and launch support will continue.

f. A backup NCC capability will exist at a location sufficiently separated from the NCC to allow independent remote operation.

1.4 REFERENCE DOCUMENTS

The following documents contain information relative to this document:

a. Tracking and Data Relay Satellite System (TDRSS) User's Guide, STDN No. 101.2, Revision 5, September 1984.

b. Ground Spaceflight Tracking and Data Network (GSTDN) User's Guide STDN No. 101.3, Revision 2, June 1980.

c. Performance Specification for Services via the Tracking and Data Relay Satellite System, S-805-1, Revision B, April 1983.

d. Tracking and Data Relay Satellite System (TDRSS) Security Classification Guide, SCG-15, April 1, 1987.

e. Tracking and Data Relay Satellite System (TDRSS) Security Classification Guide, SCG-16 (s), April 4, 1983.

f. Space Transportation System (STS) Security Classification Guide, 17 March 1986.

SECTION 2. STDN OVERVIEW

2.1 GENERAL

2.1.1 The STDN is a worldwide complex composed of both ground-based stations and orbiting relay satellites designed to provide T&DA services between approved users and their spacecraft. The network environment requires support for both classified and unclassified users, and compliance with both national resource protection and DOD security.

2.1.2 The STDN is managed and controlled by the GSFC Mission Operations and Data Systems Directorate (MO&DSD), Code 500, which has delegated responsibility to the Networks Division (Code 530).

2.1.3 The major elements that make up the STDN are as follows:

a. NCC.

b. SN.

c. GN.

2.2 NCC

The NCC is responsible for allocation of resources and control of the STDN, and performs the following functions:

a. Resource Planning and Allocation. Commits and allocates STDN resources to satisfy user support requirements. Generates support schedules and disseminates to users.

b. Network and Service Control. Maintains active control of SN services and GN support activities. Monitors activities to ensure user requirements are met and performs fault detection to assist users in restoration of services.

c. Service Assurance. Conducts fault isolation investigations into STDN problems which have impacted scheduled service, and initiates corrective action for problem resolution.

d. Service Accountability. Accounts for all activities concerning scheduled services from the STDN. Performs failure trend analysis of these services.

e. Management Control. Serves as focal point for control of all network operations.

2.3 SN

The SN consists of the following elements:

a. WSC. The WSC contains two functionally identical ground terminals which can be scheduled independently. It provides the capability for user services and for health and safety of assigned TDRS's.

b. TDRSS. TDRSS will consist of a maximum of four operational satellites.

c. BRTS. Ground transponders at four locations are tracked by the TDRS's for the purpose of obtaining metric tracking data to determine location of TDRS's.

d. TDRS System Relays. Within the TDRS System (TDRSS), several ground relays have been implemented to provide the telecommunications interface between a TDRS and user spacecraft at checkout facilities. Currently, these relays are located at Merritt Island (MIL) GN station, Vandenberg Air Force Base (VAFB), and GSFC, including the Compatibility Test Vans (CTV).

2.4 GN

2.4.1 The GN is composed primarily of diversely located 9-meter S-band ground stations and a few special STS support stations responsible for providing T&DA support to scheduled user spacecraft.

2.4.2 In this time frame, the GN emphasis will be focused on STS and ELV launch support, including prelaunch testing and validation activities.

SECTION 3. STDN OPERATIONS CONCEPTS

3.1 GENERAL

3.1.1 The STDN Program encompasses development, implementation, testing, operations, service assurance, and maintenance of the STDN. It provides resource planning services for current and future users, and, in conjunction with the Flight Mission Support Office (Code 501), develops responses, plans, and actions necessary to implement NASA-approved user requirements.

3.1.2 The STDN operates in accordance with GSFC/DOD security and national resource protection requirements, providing and maintaining secure operations.

3.1.3 The Nascom Division (Code 540) provides all necessary operational communications support for the STDN within the scope of approved requirements.

3.1.4 The NCC schedules within constraints of Nascom-provided communications services.

3.1.5 The Flight Dynamics Division (FDF), Code 550, provides prediction and acquisition data support for the STDN by processing user satellite tracking data and BRTS data for TDRSS.

3.1.6 The priorities for assigning network resources are derived from NMI 8410.2, NMI 8410.3, and a GSFC review committee. These priorities are exercised by the NCC in assigning STDN resources and for resolving conflicts. A NASA Network Manager (NM) is present in the NCC 24 hours a day, and is authorized to adjust these priorities to accommodate user needs in real-time situations.

3.1.7 The user sees only the services he receives, not the many resource allocations and STDN operations activities constantly ongoing. In essence, operational support is transparent to users.

3.1.8 The STDN must support all phases of a user mission. Support of these phases is depicted in Figure 3-1.

3.2 NCC

3.2.1 GENERAL

3.2.1.1 The NCC controls the STDN by providing resource planning and allocation, network and service control, service assurance, service accountability, and management control. Figure 3-2 depicts the NCC interfaces necessary to perform these services.

3.2.1.2 The NCC maintains contingency plans and procedures for the STDN. Elements within the STDN will have derived contingency procedures.

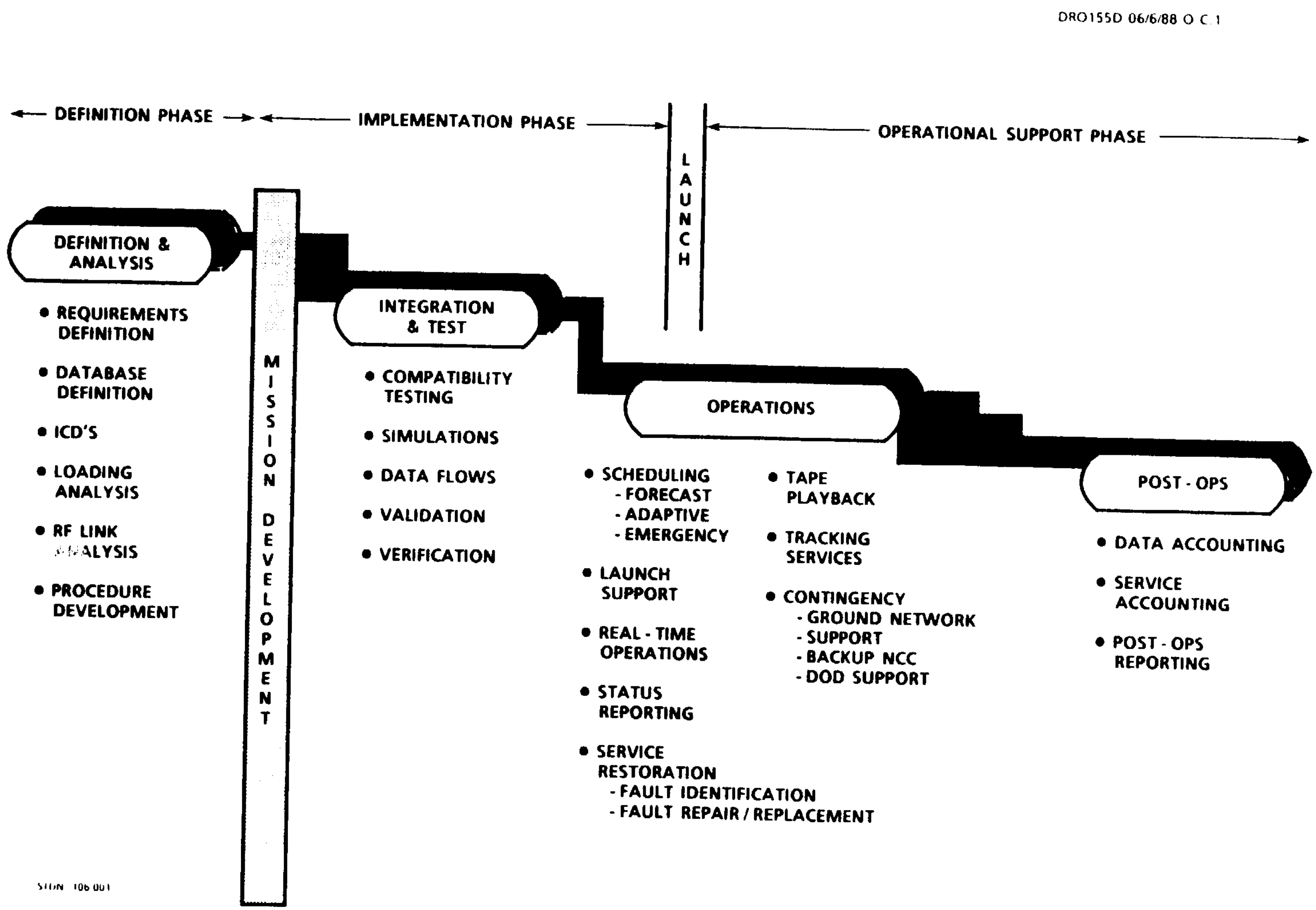

Figure 3-1. STDN Support of User Mission Phases

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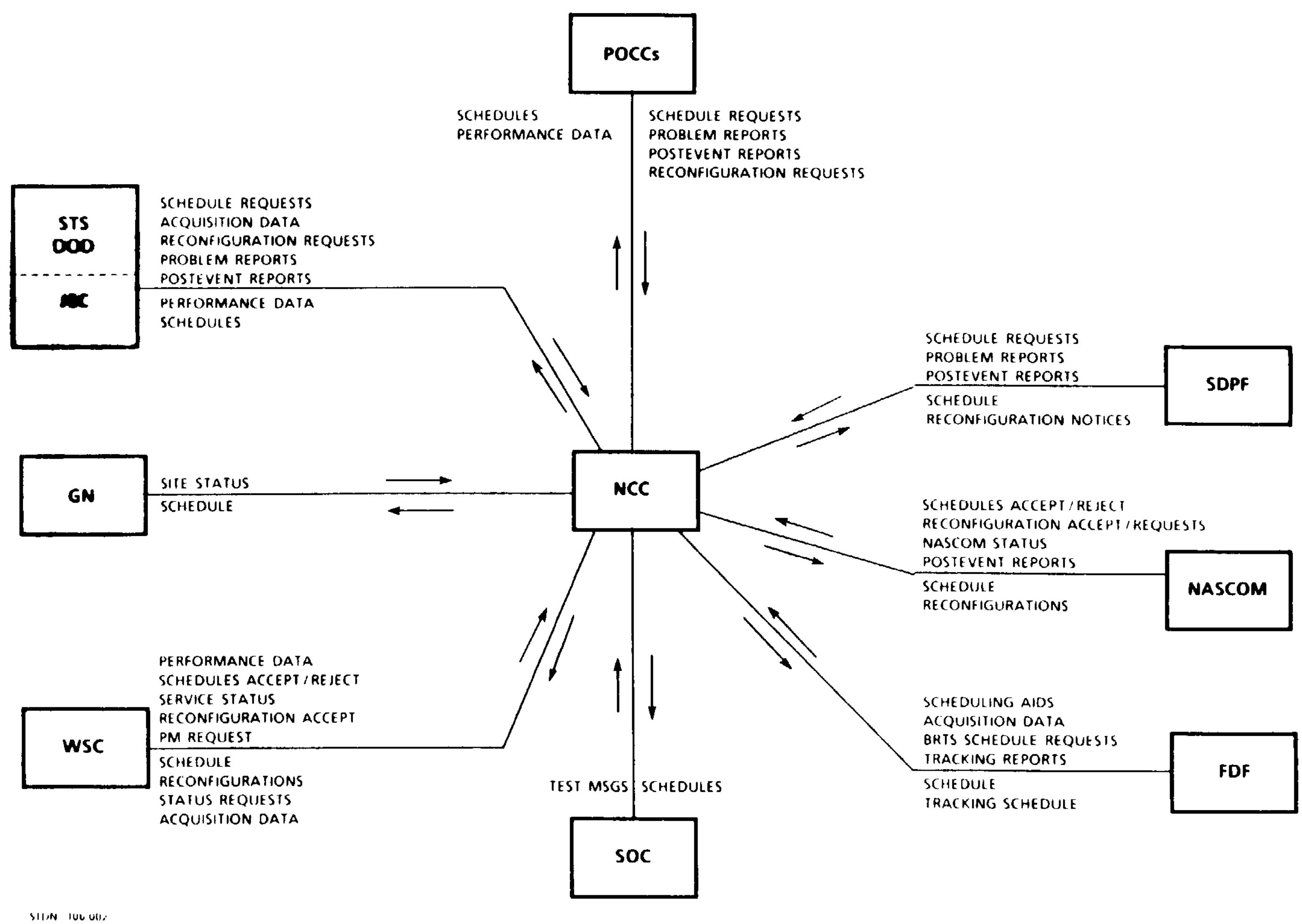

Figure 3-2. NCC Interfaces

3.2.2 RESOURCE PLANNING AND ALLOCATION

3.2.2.1 General

a. The NCC is responsible for allocation of STDN resources and operational support. It provides user access to network resources by acting as the point of contact between users and the STDN. Users communicate their requirements (schedule requests, Ground Control Message Requests [GCMR], service status, database inquiries, etc.) to the NCC which, in turn, generates appropriate scheduling and control messages to commit the necessary STDN resources to provide requested support.

b. All schedules/schedule changes for user support are issued to the STDN by the NCC. The NCC scheduling system will be manned 24 hours a day to manage schedule change requests and changes due to resource status, launch slips, etc. The forecast schedule process will be accomplished during the prime (day) shift period when both the NCC and GSFC POCC's are staffed to coordinate resource planning and resolve scheduling conflicts.

3.2.2.2 Scheduling

a. The NCC will control user support from the STDN through its scheduling process. The strategy for resource allocation is expected to shift from a user request-driven process to a process based on user commitments expressed in terms of generic requirements which the NCC can process into specific scheduling events.

b. The NCC schedules resources and services in accordance with availability of resources, which considers preventative maintenance and other scheduled downtimes, support commitments, and approved priorities.

3.2.2.3 Security. Security considerations require that the NCC resolve conflicts between SN users, and that users not negotiate directly with each other. However, GN users have access to the unclassified composite schedule and may negotiate schedule changes with other users.

3.2.2.4 Forecast Scheduling. The NCC normally schedules user events based on user-submitted specific scheduling requests; however, limited generic scheduling capability is expected to be in place for handling non-complex requirements. Generic scheduling in the secure environment is advantageous to both the NCC and user community.

3.2.2.5 Active Scheduling. Users may generate specific schedule requests at any time up to 5 minutes prior to event start time at WSC. However, the NCC will determine the selection of the specific ground station and assigned TDRS.

3.2.2.6 Contingency Scheduling. In the event of an SN failure, the NCC will mediate contingency support using the GN and resources of other networks.

3.2.3 NETWORK AND SERVICE CONTROL

3.2.3.1 General

a. Resource control entails obtaining sufficient status information to make an assessment that a service may be committed for support. User impacts are anticipated by a near-real-time review of status information on equipment, links, potential mutual Radio Frequency Interference (RFI), and service from each element. Positive accounting of status of resources is maintained at all times. Figure 3-3 depicts the STDN functional message data flow for obtaining network status.

b. Release of resources for maintenance, engineering changes, software delivery checkout, etc., is tightly controlled by a schedule.

c. Configuration freezes may be used during critical support periods such as launch support.

d. Tests and simulations are conducted to verify equipment status, ensure mission readiness, and resolve problems.

3.2.3.2 SN Status Monitoring

a. Status Information. In order to properly schedule services in response to user requirements and to provide reasonable assurance that these requirements will be satisfied, the NCC must have accurate status information concerning the services to be provided. There are two main items of consideration for the requirement of status information, as follows:

(1) Time

(a) Except for extended major systems failures, status information is not required during the forecast and early portion of the active schedule period. All available services could be considered operational during this time.

(b) In the later portion of the active schedule period, the need for detailed status information increases and it becomes important that detailed status be known when the specific support schedule is executed.

(2) Detailed Status

(a) Generally, the NCC schedules support based on geographic coverage (TDRS-E or TDRS-W); and major services such as MA, S-band Single Access (SSA),and K-band Single Access (KSA) forward and/or return links. Based on specific user requirements and TDRSS configuration, these major services (links) must be divided into subsets in order to accurately determine status to support. The NCC must also keep track of subsets of services within a major service.

(b) Because of the switching flexibility within the ground terminals, failure of a major service string does not deny support by a particular TDRS. The NCC must keep track of the number of

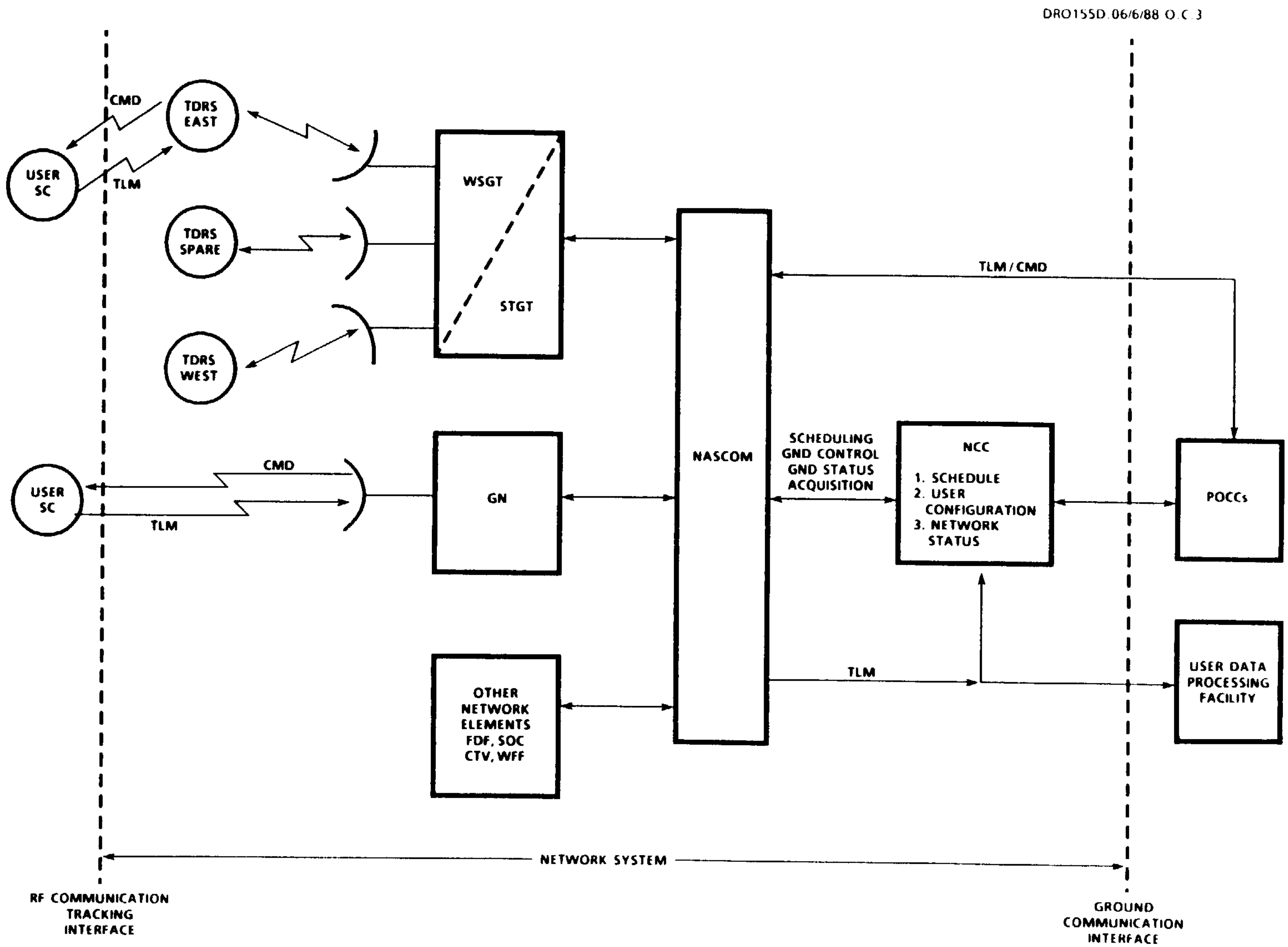

Figure 3-3. STDN Functional Message Data Flow

different ground terminal strings available versus a specific link through a particular TDRS.

(c) Failure of a specific capability within a string will cause a failover to the redundant string. An additional failure within the redundant string may not prohibit support. The NCC must have the capability to determine what portion of the string failed in order to determine if alternate support can be provided or if support can be provided to the user in a degraded mode. The user may accept degraded operational data when support of exact specifications cannot be met.

b. Monitoring by Exception. Due to the large number of simultaneous events that must be supported, a method known as monitoring by exception is required. Procedures are as follows:

(1) The SN is a message-controlled, semi-automated system. A great dependency on the NCC exists to ensure proper message content by validating incoming messages. Static and dynamic data is received from the SN to assist the NCC in performing its monitoring function. A monitoring system which accepts validated incoming messages containing this data should alert operators to changes in status of ongoing operations through a method of automatic fault detection. Displays are monitored which contain significant dynamic parameters of multiple simultaneous events for all SN services. Out-of-tolerance conditions will be highlighted indicating affected users. Operators can call up more detailed displays for the affected user, and may be presented with the condition, its impact to the user, and suggested options for determining appropriate action to be taken.

(2) Trending analyses are required to capture patterns of service, failures, and resolutions to develop options which are provided in real time to the NCC operator for assistance in determining resolutions.

(3) An NCC objective is to operate a two-station complex and four satellites with no increase in staffing.

(4) An intelligent system may be used to enhance operator capability.

3.2.3.3 GN Status Monitoring

a. In the automated operation of the NCC, a GN-automated interface is required. The Local Area Network (LAN) at each GN station has interfaces with System Utilization Enhancement (SUE) equipment, Tracking Processor System (TPS), etc. Selected static and dynamic status data automatically produced on site would be transmitted from each station to the NCC to assist in performing its monitoring function.

b. An NCC monitoring system is required which accepts this data and alerts the operators to changes in status of ongoing operations through a method of automated fault detection. Monitoring by exception would be the method of monitoring the status of the GN, as in the SN. Operators will monitor displays which contain significant dynamic parameters of the events being supported. Out-of-tolerance conditions would be highlighted to alert the operator of the condition and the user affected. Lower-level displays could be called up to provide more detailed information containing specifics of the condition, impact to the user, and suggested options available to the operator for determining a proper response. An intelligent system could be used to enhance operator capability.

c. The NCC will use technical support personnel to support launches and other critical activities.

3.2.4 SERVICE ASSURANCE

3.2.4.1 The NCC is the focal point for conducting real-time fault isolation investigations into problems which have impacted scheduled user service, and for initiating problem resolution (corrective action) by the element (WSGT, NASCOM, FDF, etc.) identified as the problem source. The user must request NCC to initiate fault isolation procedures when an anomaly is recognized.

3.2.4.2 The NCC uses a variety of tools (manual and automated) and capabilities to analyze, resolve, and report to cognizant organizations the status and resolution of STDN problems, as follows:

a. Through the Space Network Anomaly Committee (SNAC) and Daily Operations Status Meeting (DOSM), the NCC conducts investigations into STDN problems which have impacted scheduled service.

b. Based on the investigation results, the NCC initiates action to correct the cause of the anomaly. This may result in hardware, software, or procedural changes to the STDN or its users.

c. The implementation of any changes to operational documents such as the user Network Operations Support Plan (NOSP) and TDRS Network Operations Support Plan (TNOSP) is effected by the NCC.

3.2.5 SERVICE ACCOUNTABILITY

3.2.5.1 Service accountability is achieved by maintaining accurate information concerning services provided by the STDN. The automated service accounting system will be enhanced to electronically process data inputs in near real time. All routine activities such as user support, maintenance time, test time, simulations, and unused time will be logged and accounted for.

3.2.5.2 This information is used for a variety of purposes such as reimbursable billing, link utilization, and scheduling efficiency. The STDN performance records over a period of time are analyzed to determine failure trends, operator performance trends, and user spacecraft support performance.

3.2.6 MANAGEMENT CONTROL

3.2.6.1 STDN operations management will test and accept engineering systems implementations and changes. These changes will be scheduled to proceed without undue disruption to ongoing operations.

3.2.6.2 The NCC management activities are as follows:

a. A NASA Network Manager (NM) is assigned to the NCC 24 hours a day to exercise operational control within the Networks Division delegated authority.

b. A NASA Network Director (ND) is assigned to specific missions, and is responsible for managing resources allocated for that support.

c. The NCC Site Manager is responsible for NCC physical security, facility support, engineering changes, and utility support (power, communications, etc.).

d. The Mission Management Area (MMA) within the NCC is available to NASA management for viewing and monitoring operational support of designated missions.

3.3 SPACE NETWORK

3.3.1 GENERAL

3.3.1.1 The SN comprises the following:

a. Up to four orbiting TDRS's.

b. WSC, which controls the TDRS's and contains two independently scheduled ground terminals.

c. BRTS.

d. TDRSS Relays.

3.3.1.2 The WSC includes SN ground support and communications distribution functions which provide user services scheduled by the NCC.

3.3.1.3 The TDRS's will be assigned to each ground terminal by the NCC. Each ground terminal will be responsible for stationkeeping and general health and safety, as well as all user services scheduled for these TDRS's. Once made, these assignments will continue until a circumstance of sufficient magnitude arises to justify a change.

3.3.1.4 Figure 3-4 depicts the configuration for four operational TDRS's.

3.3.2 ZONE OF EXCLUSION

3.3.2.1 A Zone of Exclusion (ZOE) exists in which user spacecraft are not visible to the TDRS's. This is the result of having only a single location for ground terminals, resulting in a maximum permissible separation of 130 degrees in longitude between TDRS's. The location of the TDRS's at 41 degrees west longitude and 171 degrees west longitude causes a dead zone over the Indian Ocean that is roughly 37 degrees wide for 200-km, low-earth orbiting satellites.

3.3.2.2 User service will be scheduled to terminate prior to entering the ZOE and to resume after exiting ZOE, if required. Figure 3-5 shows the ZOE.

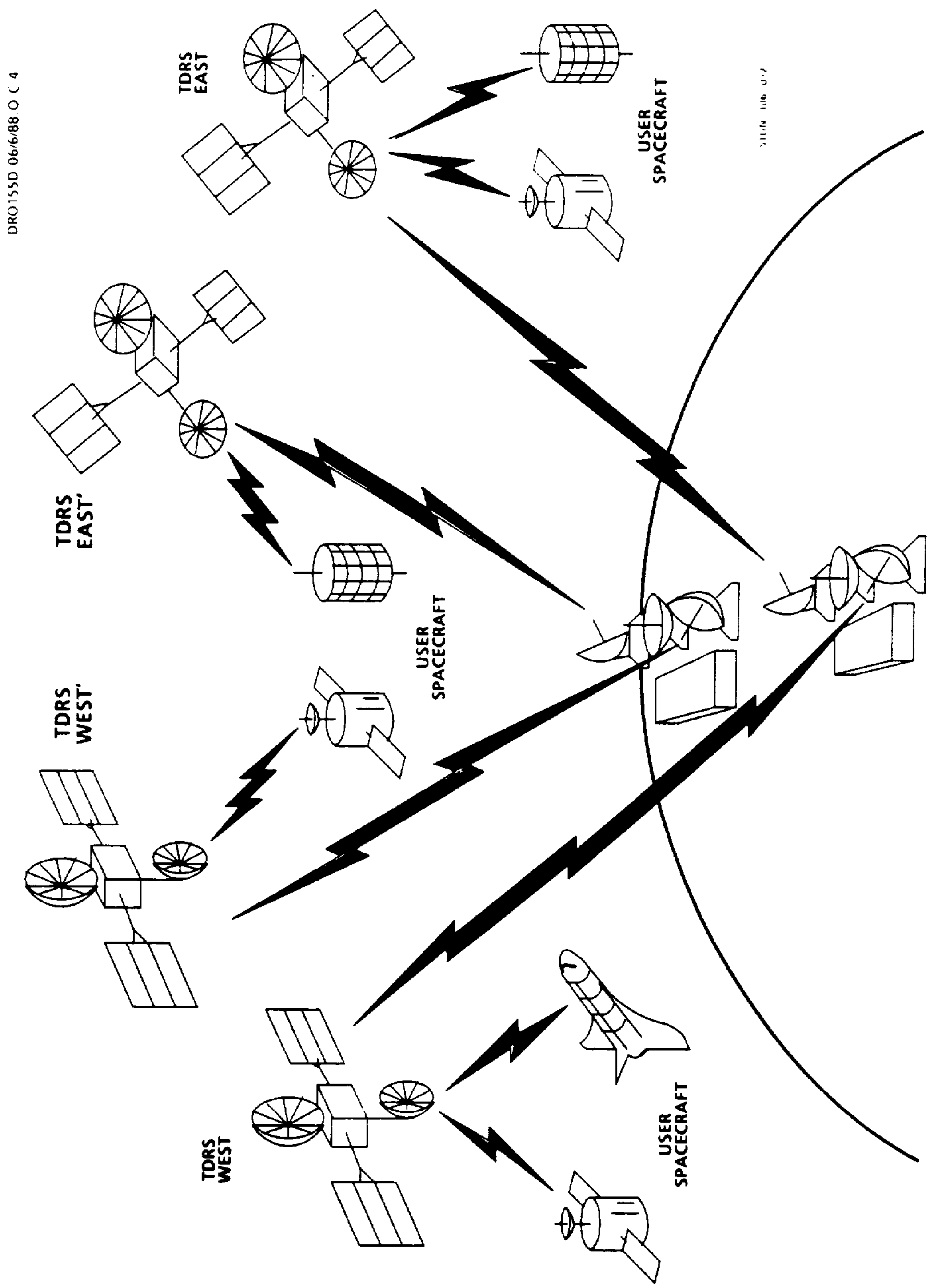

Figure 3-4. TDRSS Configuration

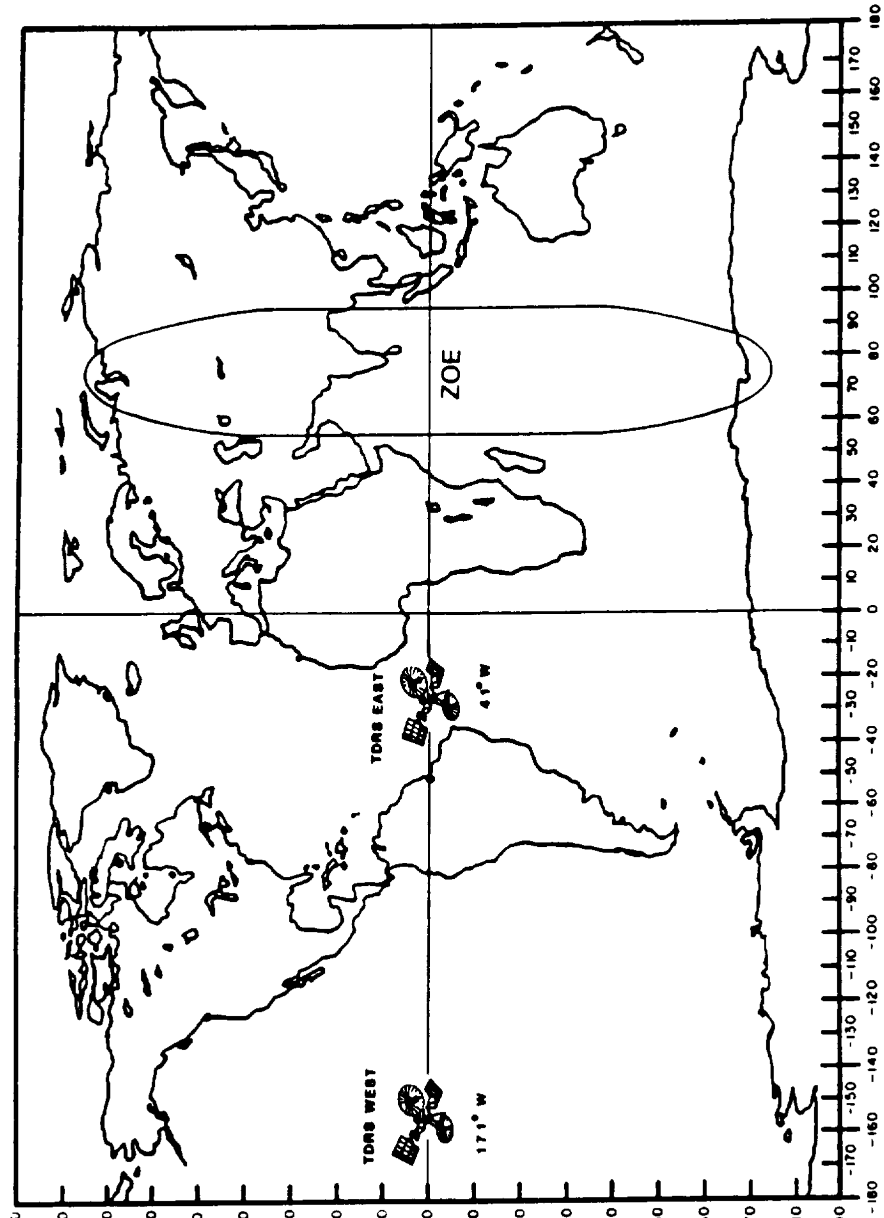

Figure 3-5. SN Zone of Exclusion (for Two-TDRS Constellation, 200-km Spacecraft Orbit)

3.3.3 WSC/NCC INTERFACE

3.3.3.1 The primary operations interface between the NCC and WSC is by means of standardized structured data messages which have been validated by the NCC. This method is backed up by voice, facsimile, and teletype communications. An intelligent system may be used to augment the operator's effectiveness to the extent possible.

3.3.3.2 The NCC will send state vectors to both ground terminals. Each ground terminal will process and use the data applicable to the assigned TDRS's, and store the remaining information for potential future use.

3.3.3.3 If any use is made of C-band services, it should be transparent to all operations and must not impact STDN services to users.

3.3.3.4 Each ground terminal is controlled independently by the NCC for all user services. No automatic failover between WSGT and the STGT ground terminals is planned or envisioned. In the event of a catastrophic failure wherein a complete ground terminal is made inoperative, user support assigned to that terminal will be reassigned to the other ground terminal at the direction of the NCC.

3.3.3.5 Redundancy is built into both ground terminals. A contingency mode transfer of control from one TT&C system to another must be accomplished in sufficient time to prevent a TDRS Emergency Time Out (ETO).

3.3.3.6 TDRS launch configuration and deployment operations are the responsibility of the TDRSS Project (Code 405), and will be conducted from WSC or designated backup facilities.

3.3.3.7 TDRS replenishment strategy plans establish the conditions under which additional spacecraft will be launched (i.e., Space Network 10-year Plan and TDRS Contingency Plan).

3.3.4 STGT/WSGT INTERFACE

3.3.4.1 General

a. Intersite tie lines between the two ground terminals at the WSC will enable orderly handover of TDRS spacecraft between ground terminals. This will enable rapid transfer of database information, and permit simultaneous monitoring of TDRSS telemetry data at a central office from two independent TT&C systems.

b. These intersite tie lines will also allow a single TDRS simulator to drive any of the TT&C systems for training.

3.3.4.2 Operations Data Communications. User data will be managed at the WSC in such a manner as to ensure delivery while reducing the cost of common carrier service to transport data away from WSC to the appropriate POCC or SDPF. Communications are as follows:

a. Low Data Rate Communications. Low data rate (less than 2 megabits) communications used to support user command and return data are controlled by NCC schedules, with local control possible for contingency operations and maintenance, as follows:

(1) Data will be handled by Nascom in a redundant broadcast mode operating simultaneously.

(2) Each terminal will be a source, one designated prime and the other backup (alternate).

(3) Data from/to each facility will be separately interfaced to both the prime and backup terminals.

(4) Nascom will conduct fault isolation of communications equipment (and common carrier services) on NCC request.

b. High Data Rate Communications. High data rate (more than 2 megabits) communications service will be provided as follows:

(1) Each ground terminal will have a transmission capability configured in a redundant broadcast mode.

(2) Data from both sites can be transmitted simultaneously by use of tie lines to provide isolation and backup in case of failure.

(3) Tie lines are configured locally; however, specific tie lines can be allocated for control by the local scheduling equipment, which derives its schedule from the NCC.

3.3.4.3 Software Development. An independent software development capability is required by WSC and NCC. Software enhancement and development will be conducted without impacting real-time operations.

3.4 GROUND NETWORK

3.4.1 GENERAL

3.4.1.1 A continuing need exists for a GN which is capable of providing S-band TT&C services for contingency and launch support.

3.4.1.2 In addition, these stations will contain capabilities for unique services such as C-band tracking, range safety command and telemetry, and STS Ultrahigh Frequency (UHF) voice and video.

3.4.1.3 The GN will evolve towards automated operations when it is cost-effective. The automated interface with users and the NCC requires less operator intervention.

3.4.1.4 GSFC will continue to augment the GN, as required, by obtaining support from other networks/stations to carry out responsibilities as Lead Center for NASA T&DA support.

3.4.2 ROLE

3.4.2.1 General. The GN primarily provides support to prelaunch testing, launches, and STS landings. In addition, the capability remains to provide support to spacecraft emergencies or contingencies including STS, TDRS, and other NASA missions.

3.4.2.2 Prelaunch. MIL acts on behalf of GSFC to interface with Kennedy Space Center (KSC) for support of ELV and STS prelaunch activities (both classified and nonclassified). All committed network resources are scheduled by the NCC.

3.4.2.3 Launch. MIL/Ponce de Leon (PDL) and Bermuda (BDA) are the primary launch support stations. Network management and technical control are provided by the NCC.

3.4.2.4 Orbital Support. The GN is required to provide orbital support to approved missions, and to augment SN support. It will be the prime network for support of new TDRS deployments, during drift to on-orbit station locations, etc. GN stations will normally interface directly with the user POCC for orbital support.

3.4.2.5 STS Landing. A continuing requirement remains for GN support of all STS landings.

3.4.2.6 Backup/Contingency/Emergency Support. The GN will provide a backup capability to the STS and TDRS's in the event of an SN anomaly. Contingency and/or emergency support capability for on-orbit NASA spacecraft will be retained. It will be exercised only on specific direction from the NCC.

SECTION 4. USER/STDN INTERFACE CONCEPTS

4.1 STDN USERS

4.1.1 This section describes how users interface with the STDN and, in particular, the interface with the NCC necessary to schedule and conduct operations.

4.1.2 The term user is defined as any NASA Headquarters-approved project requiring operational support from STDN resources. The STDN provides T&DA support to a wide variety of NASA flight projects with POCC's located at NASA centers and other locations.

4.1.3 In addition to NASA projects, the STDN supports cooperative programs with other organizations (both foreign and domestic), or on a reimbursable, non-interference basis.

4.1.4 Users may interface verbally or via various electronic communications media for assistance.

4.2 SCHEDULING INTERFACE

4.2.1 GENERAL

4.2.1.1 All STDN resources are scheduled by the NCC. A user may obtain support by submitting specific schedule requests or establishing generic requirements to the NCC. After users' requirements are interpreted into specific events by the NCC, each user is provided with a copy of their forecast schedule.

4.2.1.2 Provisions exist within the scheduling system for a user to make schedule adjustments as operational needs may change. Such changes may be made as long as they do not adversely impact prior commitments to another user. The NCC is sensitive to the user's need for a reliable operations schedule.

4.2.1.3 Objectives of the NCC/user interface are to:

a. Provide standard interface protocols which allow users to convey generic or specific schedule requests.

b. Allow the NCC flexibility to modify schedule requests to match resource availability.

c. Satisfy the minimum requirements of all users through use of the priority list and scheduling process.

d. Perform forecast scheduling during the prime shift when NCC and user staffing levels permit the necessary interaction to occur for conflict resolution.

e. Allow users to request network resources and services in a simple, non-complex manner.

f. Provide a scheduling system that will process both specific and a limited series of generic schedules in a secure environment.

4.2.2 STDN SCHEDULING

4.2.2.1 Scheduling of STDN resources is accomplished by the NCC primarily through specific schedule requests provided by the POCC. All changes to the STDN schedule must be processed and scheduled by the NCC as part of the formal resource commitment.

4.2.2.2 The NCC consolidates all schedule requests and issues a composite GN schedule to all GN users. The GN users are permitted to negotiate with each other for changes to the schedule.

4.2.2.3 The SN composite schedule is classified and is not available to all SN users. Each SN user is provided with a forecast schedule consisting exclusively of its own events. Request for SN support changes must be submitted to the NCC which will perform the coordination necessary to accommodate the needs of all users.

4.2.2.4 The TDRSS and STS Security Classification Guides require the NCC to provide resource protection about certain kinds of SN information.

4.2.3 SN SCHEDULING

4.2.3.1 A user may indicate coverage by TDRS-E or TDRS-W. However, the NCC will determine the TDRS at the east or west locations and the actual ground terminal (WSGT or STGT) to provide the support. This approach to scheduling SN resources affords the NCC increased flexibility in the resource allocation process while improving the probability of meeting operational needs of all users.

4.2.3.2 The NCC is responsible for the following:

a. Selection of the specific TDRS (E, E' or W, W') to meet user operational requirements.

b. Designation of the ground terminal (WSGT or STGT) which will be used.

c. Notification to the POCC via forecast and active schedules of the TDRS selection.

4.2.3.3 The POCC is responsible for generating onboard computer command loads (if required) for antenna pointing to the TDRS scheduled for support.

4.3 STATUS INFORMATION

4.3.1 GENERAL

4.3.1.1 STDN users require network status information to properly plan mission activities n advance of the scheduled period.

4.3.1.2 In addition, operational status of scheduled resources is required by users during actual support to determine if out-of-tolerance conditions may exist which will affect the quality of data.

4.3.2 PLANNING STATUS

Occasionally, extended system outages may occur as a result of temporary failures, equipment modification and refurbishment, or permanent failures such as the TDRS-1 Ku-band forward link. The NCC will notify users of scheduled downtime when appropriate. Unscheduled outages will also be communicated to all users when it is determined that the outage will affect the forecast period.

4.3.3 REAL-TIME STATUS

4.3.3.1 Operational status information is provided by the STDN for all users. This status provides the user with information pertinent to systems performance during scheduled events. Real-time status information is available to users through an automated interface. In addition, status information may be verbally provided directly from the stations to the user for GN support, and by the NCC to the user for SN support.

4.3.3.2 Within the SN, User Performance Data (UPD), GCMR accept/reject status, and Fault Isolation Monitoring System (FIMS) type of data for STS only, are types of status data provided to users. The POCC has some degree of control over reconfigurable resources through the GCMR and can determine performance of the supporting system by monitoring UPD. The high level of automation in the message-driven SN environment diminishes the need for extensive verbal exchange. The SN is capable of being operated in a semi-automated mode through the use of formal message protocols for systems configuration and status information. The operations concept provides for persons in the loop at the appropriate level of involvement.

4.3.3.3 Status information is used by the NCC and user POCC to:

a. Determine the status of user services (NCC/POCC).

b. Initiate fault isolation procedures and involve the elements necessary to resolve operational problems (NCC/POCC).

c. Provide the basis for determination of network service availability and user reimbursement (NCC).

d. Adjust schedules in near real time to avoid impacting support to a user when a capability is lost (NCC).

4.4 VOICE COORDINATION

4.4.1 GENERAL

All STDN users are required to have a voice coordination interface capability with the NCC. This interface can be used to coordinate the scheduling process or to conduct real-time operations. Voice coordination differs between the GN and SN during real-time operations.

4.4.2 SN VOICE COORDINATION

4.4.2.1 All voice coordination for SN users is between the NCC and POCC.

4.4.2.2 Fault isolation and scheduling are the principal needs for voice coordination in an SN operation.

4.4.3 GN VOICE COORDINATION

4.4.3.1 GN users have the capability to communicate directly with the NCC and supporting stations. During critical activities, the arrangement allows the POCC's to relay pass activities to station personnel who configure systems. Station controllers provide status information which may include acquisition of signal, signal strength, decommutator lock status, etc., to operators within the POCC's.

4.4.3.2 The GN is evolving into more of an automated operation, which will reduce the need for verbal information exchange.

4.4.3.3 The NCC monitors pass activities and provides technical assistance when problems arise.

4.5 <u>OPERATIONS SUPPORT PLANS</u>

4.5.1 All users must develop written operational plans with the Networks Division as a prerequisite to implementing testing, simulations, and real-time support. The NOSP for GN support and TNOSP for SN support are the documents that describe operational usage of network resources and system capabilities to provide user support.

4.5.2 The STDN support configurations must be jointly developed and validated prior to inclusion in the NCC database. Validation includes end-to-end data flow among all supporting elements in operational configurations required by the user.

4.6 <u>STDN CONFIGURATION MANAGEMENT</u>

4.6.1 GENERAL

The NCC exercises a greater degree of control over the STDN during prelaunch and launch activities than is normally used for routine orbital support. This is due to the criticality of activities during launch and early-orbit operations.

4.6.2 LAUNCH SUPPORT (STS)

The NCC assumes an active role in STDN control and data monitoring during prelaunch, launch, and early-orbit operations. A building-block approach to mission support readiness verifies all support configurations, provides personnel training, and demonstrates operational readiness. The NCC is responsible for the following:

a. Conducting tests and data flows to verify support configurations, and to analyze and isolate STDN problems.

b. Conducting premission simulations and mission readiness tests.

c. Monitoring command, telemetry, tracking, acquisition data, and site status messages.

d. Directing STDN elements during prelaunch countdown support.

e. Verifying user operational interfaces with all STDN elements.

f. Monitoring the SN FIMS type of data to detect fault isolation.

APPENDIX. SPACE NETWORK AUGMENTATION

A.1 GENERAL

The launch of additional TDRS's, implementation of the STGT, and retrofit of the existing WSGT will occur between 1988 and 1994. Based on current plans and schedules, six distinct phases of operation are identified during this transitional period. This appendix presents a definition of each phase and a description of a candidate operational scenario which could be used to meet support requirements during this era. This information is based on planning schedules available at the time of document printing, such as the STS manifest, STGT becoming operational, and WSGT retrofit.

A.2 OPERATIONAL PHASES

A.2.1 GENERAL

Six different operational phases are associated with the different SN configurations described in the following paragraphs and depicted in Table A-1 and Figures A-1 through A-6.

A.2.2 PHASE 1 (1988)

This network configuration follows launch and checkout of TDRS-C, which will become TDRS-2 at 171 degrees W longitude. The WSGT will be responsible for the simultaneous operation of TDRS-1 and TDRS-2 scheduled by the NCC for user support. In addition, they will provide all TT&C for both spacecraft.

A.2.3 PHASE 2 (1989)

This network configuration follows launch and checkout of TDRS-D, which will become TDRS-3 at 41 degrees W; TDRS-1 is then relocated. At this new location, TDRS-1 will be maintained as a spare. This will be accomplished using the central K-band TT&C. The NCC will not schedule services through TDRS-1 in order to maintain the Central chain user services equipment in a hot standby backup to the North and South chains. At this time, two fully operational TDRS's will be available to provide user services. The interface with the NCC will be the same as in Phase 1.

A.2.4 PHASE 3 (1990-1992)

The network configuration during this phase will be two operational TDRS's with a fully operational spare and TDRS-1. If TDRS-1 continues to be a viable spacecraft prior to launch of TDRS-E, it will be supported as required by the GN, WSGT S-band TT&C, or, as soon as it becomes available, the STGT S-band TT&C system. The spare TDRS spacecraft (TDRS-4) will be maintained in an all-up operational mode using the central K-band Space-to-ground Link (SGL). If required, the option exists of using TDRS-4 for operational support based on mission loading and critical mission support using the Central chain. This of course, eliminates the back-up provision the Central chain normally provides to the North and South chains. Under normal conditions, the spare TDRS will not become a routine scheduable resource. The NCC functions would remain the same as described in Phase 1.

Table A-1. STDN Augmentation Phases

STDN Elements	Phase 1 1988	Phase 2 1989	Phase 3 1990 - 1991	Phase 4 1992	Phase 5 1993	Phase 6 1994
GN	MIL/PDL & BDA-SUE operational Ascension Island (ACN), Santiago (AGO), Guam (GWM), & Hawaii (HAW) Programmable Data Formatter-Plus (PDF+) operational Dakar (DKR) & Yarragadee (YAR) - Staffed for STS support only DSN 26-M - Scheduled as required by NCC	MIL/PDL & BDA - Continue operational Extended Closure Stations (ACN, AGO, DKR, GWM, HAW) - Reduced services with possibility of some stations closing DSN 26-M - Scheduled by JPL at request of NCC for STDN contingency support	MIL/PDL & BDA - Provide launch, range safety, and contingency support, as required Extended Closure Stations (ACN AGO, DKR, GWM, HAW) Limited contingency support DSN 26-M - Limited contingency support as scheduled by JPL	No changes from Phase 3	No changes from Phases 3 and 4	Same as Phases 3, 4, and 5
SN	TDRS-1 - Operational in a degraded mode TDRS-C - To be launched from STS-26. Following checkout, it will be positioned at 171°W longitude as the TDRS-2 satellite WSGT - Provides operational support for TDRS-1 & -2 NGT & Nascom - Will both undergo modification to provide a more automated service	TDRS-1 - Continues as operational spare in a degraded mode TDRS-2 - Fully operational as TDRS-W TDRS-D - After launch and checkout, becomes operational as TDRS-3 at 41°W longitude WSGT - Provides operational support to TDRS -1, -2, and -3	TDRS-1 - Operational as contingency spare in a degraded mode TDRS-2 and -3 - Continue fully operational at 171°W and 41°W longitude TDRS-E - Launched, checked out, and positioned as a fully operational TDRS spare WSGT - Provides operational support for TDRS-2, -3, and -4: and provides TT&C services to TDRS-1	Same as Phase 3, except: STGT undergoes Integration and Test (I&T) phase and becomes operational STGT assigned operational responsibility for two of the four TDRS's	WSGT undergoes retrofit STGT assumes operational responsibility for TDRS-2 & -3, and TT&C for TDRS-4 & -1	TDRS-2, -3, & -4 - fully operational and independently scheduled; TDRS-1 - fully operational and scheduled in a degraded mode WSGT & STGT - Operational and independently scheduled by the NCC which share responsibilities of four operational TDRS's

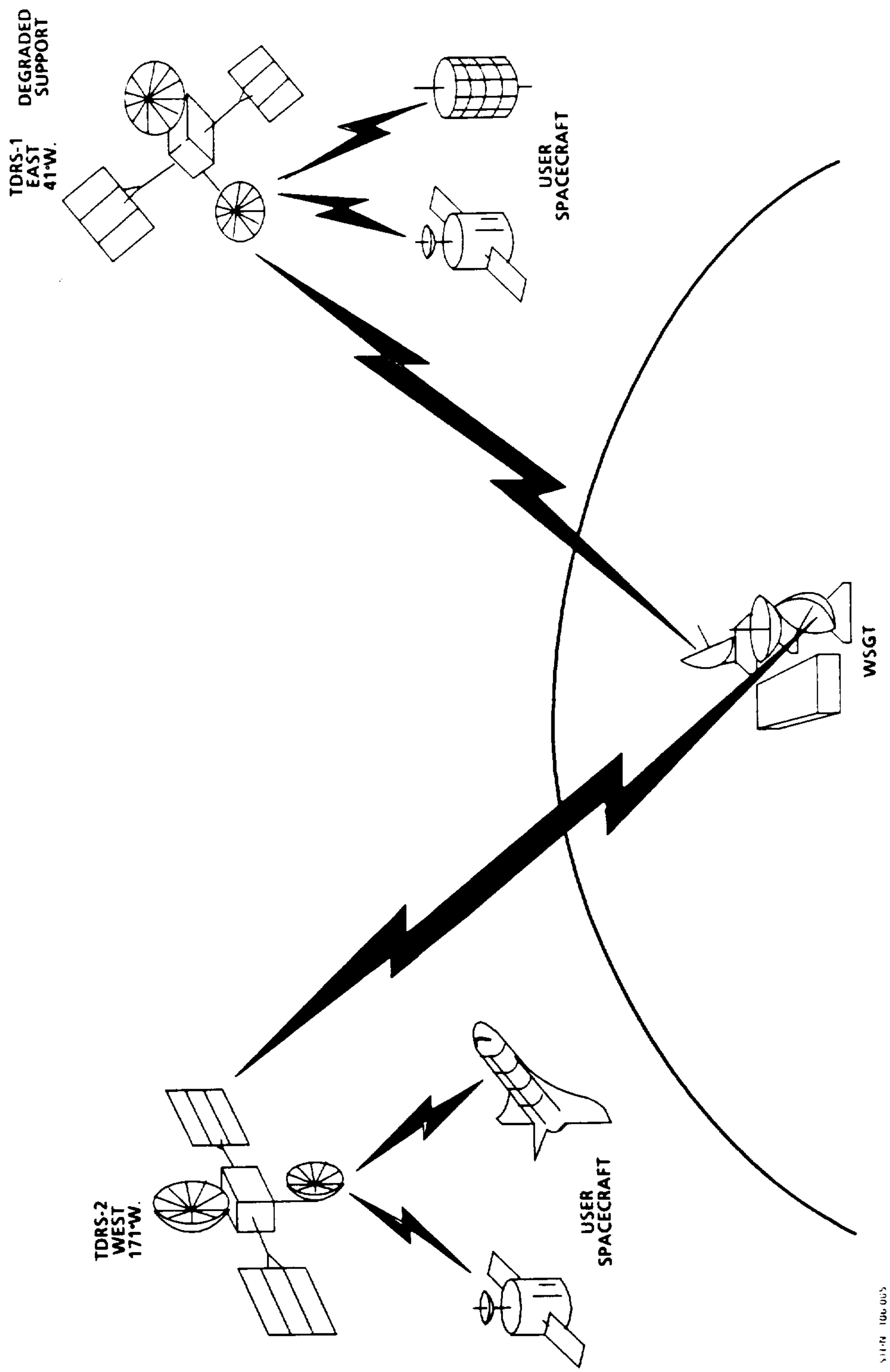

Figure A-1. Phase 1 (1988)

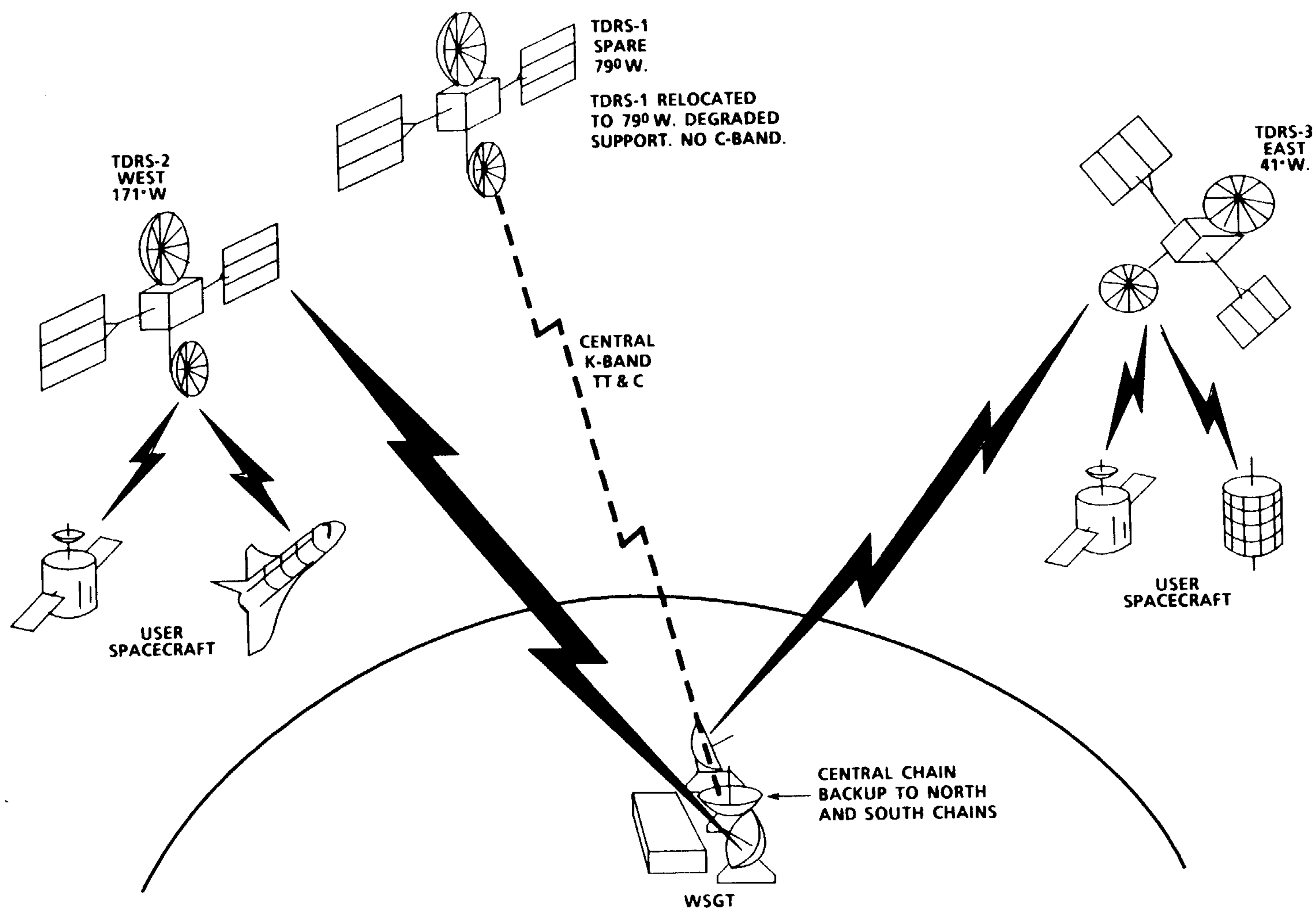

Figure A-2. Phase 2 (1989)

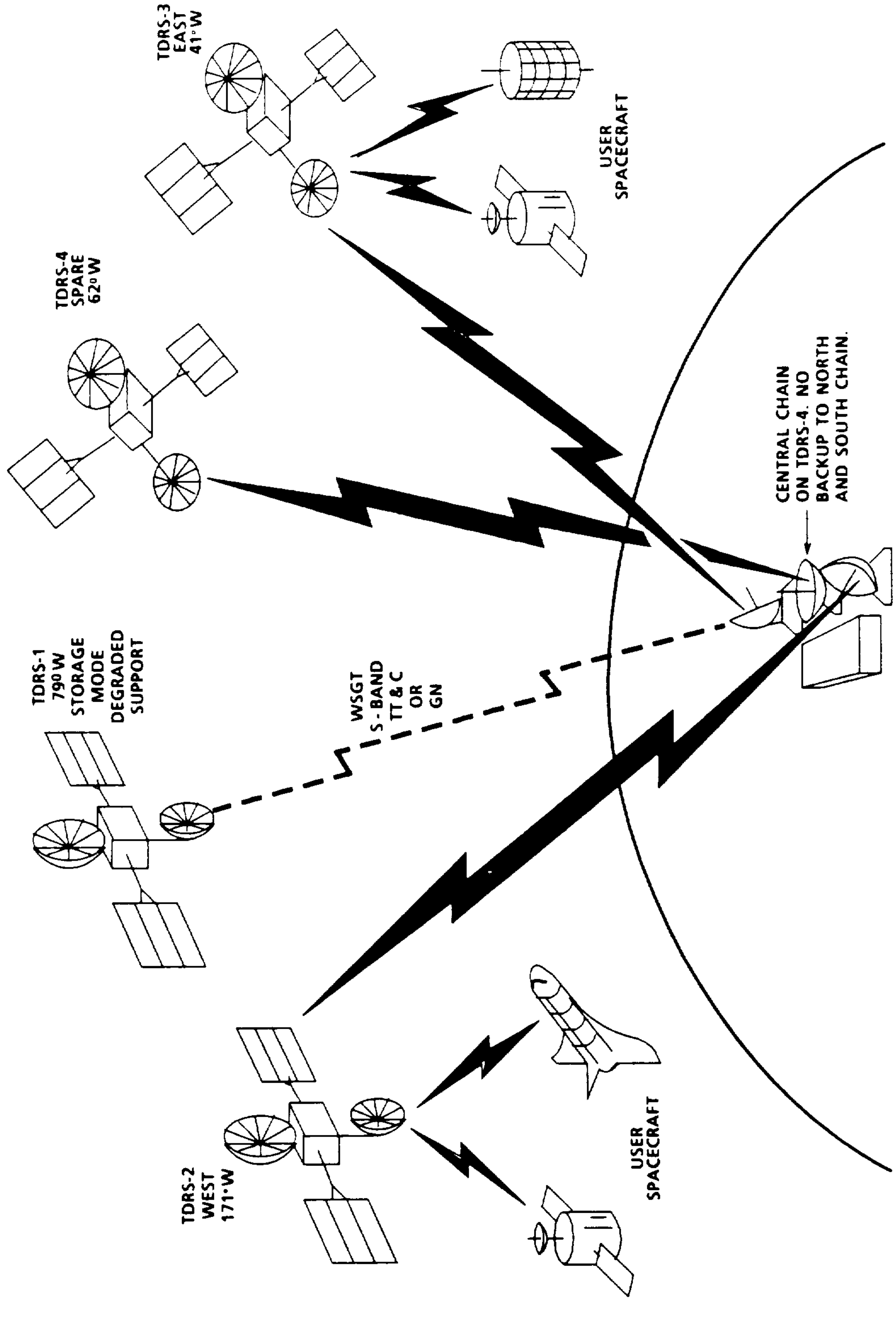

Figure A-3. Phase 3 (1990-1991)

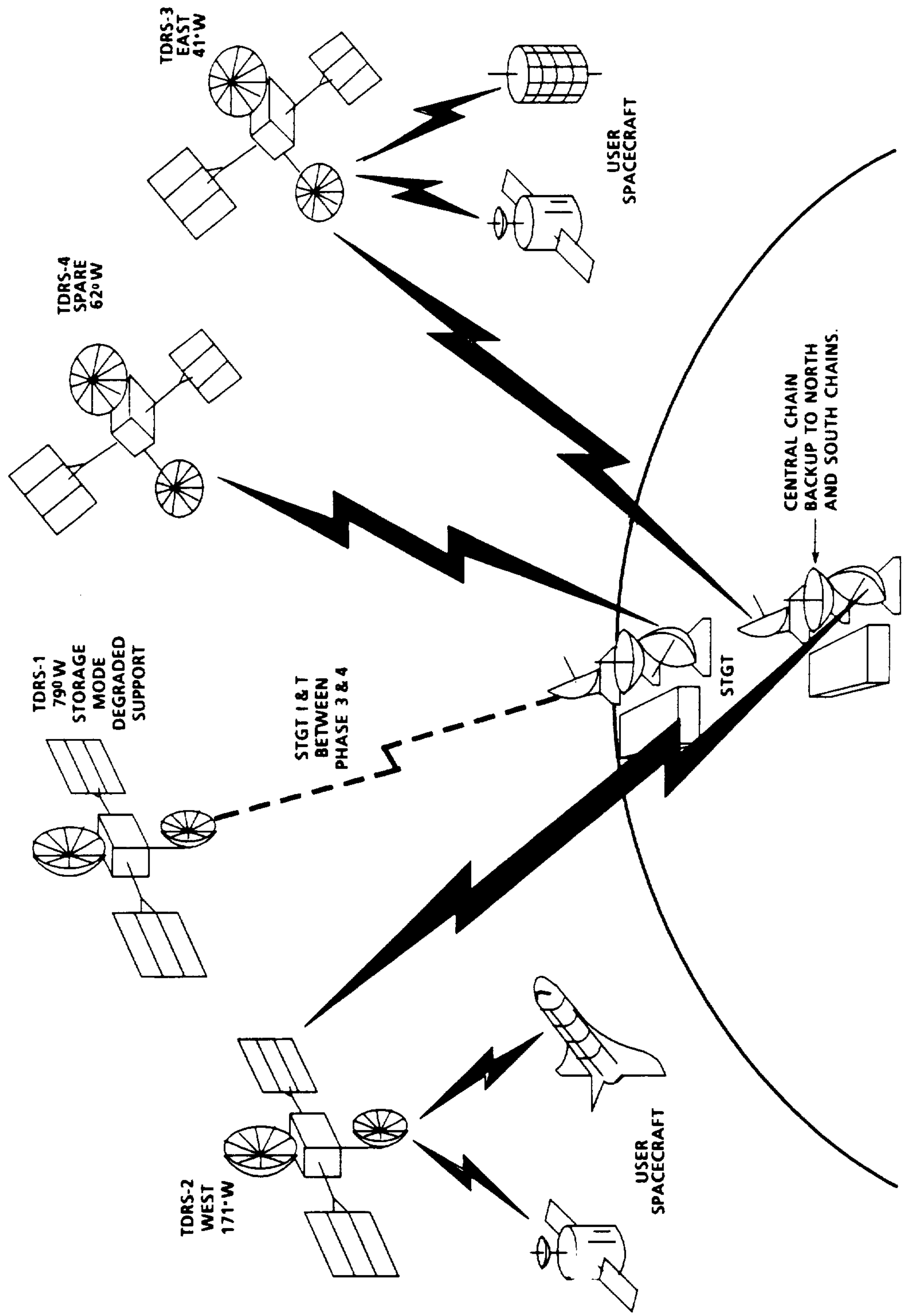

Figure A-4. Phase 4 (1992)

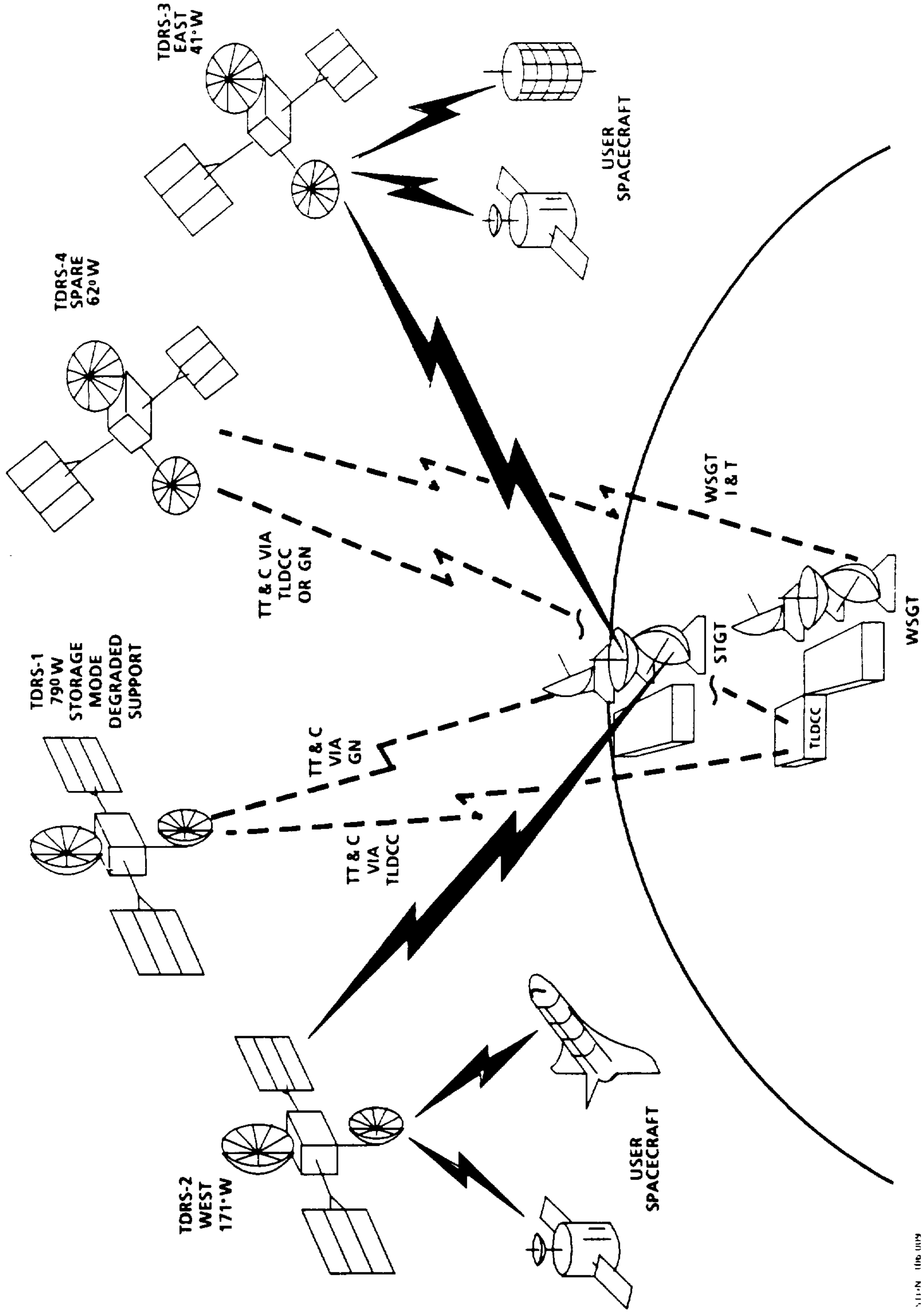

Figure A-5. Phase 5 (1993)

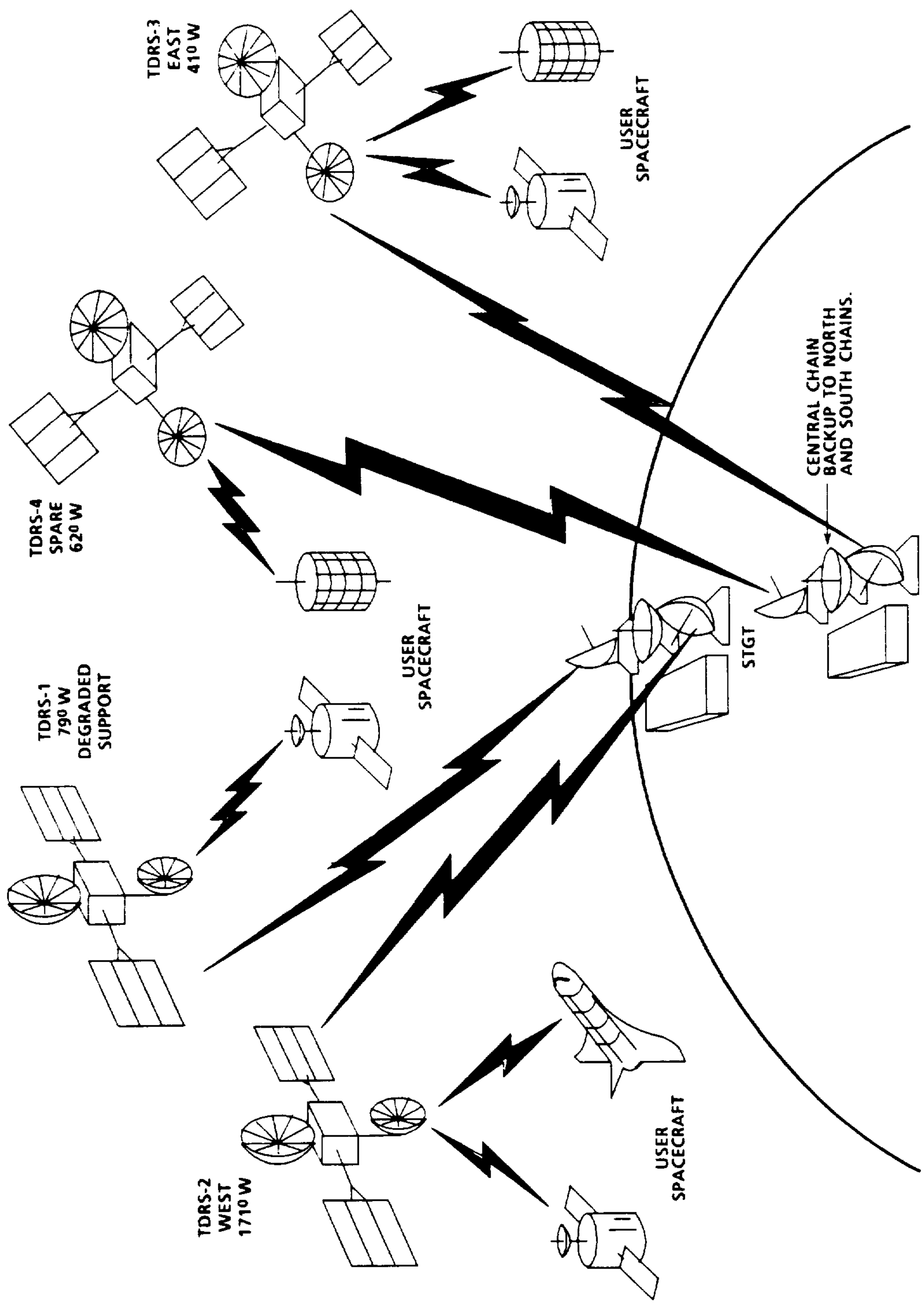

Figure A-6. Phase 6 (1994)

A.2.5 PHASE 4 (1993)

A.2.5.1 The network configuration during this phase is two operational TDRS's, a fully operational TDRS spare, and TDRS-1. STGT is operational as an independently scheduled facility.

A.2.5.2 Between Phase 3 and Phase 4, TDRS-1 will be used for I&T of STGT. After completion of I&T, one ground terminal will be assigned to an operational TDRS and the spare TDRS, and the other ground terminal will be assigned the second operational TDRS and TDRS-1. Since WSGT will only be supporting two TDRS's, the Central chain is available as a full backup spare.

A.2.5.3 The NCC sends state vectors to both ground terminals, force models to WSGT, and scheduling data to the applicable ground terminal at WSC. Individually, each activates the schedule which applies to the operational TDRS assigned to it. The NCC will receive UPD from both ground terminals. In the event of outage, backup capability is provided by resources within each ground terminal. Should a total failure occur at a ground terminal, the NCC will direct the remaining ground terminal to establish the SGL between both operational TDRS's. After reconfiguration, the ground terminal will provide user services scheduled/rescheduled by the NCC via the assigned TDRS's.

A.2.6 PHASE 5 (1994)

A.2.6.1 Phase 5 will be that interval of time during which WSGT will be retrofitted to conform to the same configuration as STGT. This retrofit period is expected to take 12 months and encompass NGT.

A.2.6.2 During the time that WSGT is down for these modifications, STGT will be assigned responsibility for all TT&C functions for three orbiting TDRS's and all user support services through the operational TDRS's. The TT&C functions for the fourth orbiting TDRS will be performed by a combination of use of the TLDCC in WSGT and the GN using a ground network interface in STGT.

A.2.6.3 During this period, only two operational TDRS's can be supported due to the operational configuration of STGT. It must be recognized that the potential exists that some user services may need to be curtailed or reduced. If this situation is not acceptable, one alternative is to retrofit WSGT in phases, maintaining a capability of providing services to users through one chain/TDRS while the rest of the system is retrofitted. The penalty of doing the retrofit this way is an increase in both cost and time for completion.

A.2.6.4 A second alternative is to exercise options to provide a third chain at STGT, enabling it to support three operational TDRS's. This would provide better long-term capabilities and minimize time of retrofit to WSGT. During this phase, both TDRS-1 and TDRS-4 are available for I&T of WSGT.

A.2.7 PHASE 6 (1995)

A.2.7.1 This phase is the period following retrofit of WSGT. Two ground terminals will be independently operated and scheduled, and four operational TDRS's will be scheduled by the NCC for user services. Two TDRS's will be assigned to each ground terminal. The NCC will determine which ground terminal is scheduled for each user.

A.2.7.2 The NCC will send state vectors to the WSC where they will be distributed to both ground terminals. The ground terminal will process and use the data applicable to the assigned TDRS's, and store the remaining information for potential future use.

A.2.7.3 Schedules transmitted to WSC will be distributed to the individual ground terminal which has been designated by the NCC to support a specific event.

A.2.7.4 In the event of a catastrophic failure wherein a complete ground terminal is inoperative, user support scheduled to that terminal can be rescheduled to the other ground terminal at the discretion of the NCC. No automatic failover between WSGT and STGT is planned or envisioned.

GLOSSARY

Term	Definition
ACN	Ascension Island, United Kingdom, GN station
AFSCN	Air Force Satellite Control Network
AGO	Santiago, Chile, GN station
BDA	Bermuda, United Kingdom, GN station
BRTS	bilateration ranging transponder system
CAN	Canberra, Australia, DSN 26-meter subnet station
CCAFS	Cape Canaveral Air Force Station
CNES	Centre National d'Etudes Spatiales (France)
CTV	compatibility test van
DFRF	Dryden Flight Research Facility
DFVLR	Deutsche Forschungs und Versuchsanstalt fuer Luft und Raumfahrt
DKR	Dakar, Senegal, GN station
DOD	Department of Defense
DOSM	daily operations status meeting
DSN	Deep Space Network
ELV	expendable launch vehicle
ESA	European Space Agency
ESMC	Eastern Space and Missile Center
ETO	emergency time out
ETR	Eastern Test Range
FDF	Flight Dynamics Facility
FIMS	fault isolation and monitoring system
GCMR	ground configuration message request
GDS	Goldstone, California, DSN 26-meter subnet station

Term	Definition
GN	Ground Network
GSFC	Goddard Space Flight Center
GWM	Guam, Mariana Islands, GN station
HAW	Kauai, Hawaii, GN station
IPD	Information Processing Division
I&T	integration & test
IUE	International Ultraviolet Explorer
JPL	Jet Propulsion Laboratory
JSC	Johnson Space Center
KSA	K-band single access
KSC	Kennedy Space Center
LAN	local area network
LeRC	Lewis Research Center
LSD	Logistics Support Depot
MA	multiple access
MIL	Merritt Island, Florida, GN station
MMA	mission management area
MO&DSD	Mission Operations and Data Systems Directorate
MSFC	Marshall Space Flight Center
MSOCC	Multi-satellite Operations Control Center
NASA	National Aeronautics and Space Administration
Nascom	NASA Communications Network
NASDA	National Space Development Agency (Japan)
NCC	Network Control Center
ND	Network Director

Term	Definition
NGT	NASA Ground Terminal
NM	Network Manager
NOAA	National Oceanic and Atmospheric Administration
NOSP	network operations support plan
NSP	NASA support plan
PDF	programmable data formatter
PDF+	PDF-Plus
PDL	Ponce de Leon, Florida, GN station
POCC	Project Operations Control Center
PRD	program requirements document
RFI	radio frequency interference
RID	Madrid, Spain, DSN 26-meter subnet station
SA	single access
SDPF	Sensor Data Processing Facility
SIRD	support instrumentation requirements document
SN	Space Network
SNAC	Space Network Anomaly Committee
SOC	Simulation Operations Center
SPIF	Shuttle POCC Interface Facility
SSA	S-band single access
ST	Space Telescope
STDN	Spaceflight Tracking and Data Network
STGT	Second TDRSS Ground Terminal
STS	Space Transportation System
SUE	Systems Utilization Enhancement

Term	Definition
T&DA	tracking and data acquisition
TDRS	Tracking and Data Relay Satellite
TDRSS	Tracking and Data Relay Satellite System
TLDCC	TDRS Launch and Deployment Control Center
TNOSP	TDRSS network operations support plan
TPS	tracking processor system
TT&C	telemetry, tracking, and command
UHF	ultra-high frequency
UPD	user performance data
VAFB	Vandenberg Air Force Base
WFF	Wallops Flight Facility
WSC	White Sands Complex
WSGT	White Sands Ground Terminal
WSMC	Western Space and Missile Center
WTR	Western Test Range
YAR	Yarragadee, Australia, GN station
ZOE	zone of exclusion

ORGANIZATION	NAME	COPIES
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GSFC/541	SALZBERG, IRVING M.	2
GSFC/541.3	BUTLER, THOMAS E.	1
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GSFC/542.2	VOELKEL, JOHN C.	1
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GSFC/554.1	STENGLE, THOMAS H.	1

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GSFC/560	KOSCHMEDER, LOUIS A.	1
GSFC/563	BANKS, MELVIN D.	1
BFEC/534.4	SERVICE SUPPORT LIB	2
BFEC/DCQA	MCDOWELL, JOHN C.	1
BFEC/DXG/SEO	CONFER, GLENN E.	1
BFEC/EDU	CAMMAROTA, EDMOND P.	1
BFEC/ENG	CONRAD, JAMES E.	1
BFEC/FSG	LACEY, CHARLES T.	1
BFEC/LIB	CENTRAL LIBRARY	2
BFEC/NCC	DUFFY, DANIEL J.	1
BFEC/NCC LIB	HANDY, GLADYS R.	1
BFEC/ND	RHODERICK, GARDINER W.	1
BFEC/NOG	HITCH, HOWARD C.	1
BFEC/NSO	RICHARDS, EDGAR H.	1
BFEC/NTTF	KULAK, M. EDWARD	1
BFEC/NTTF	NTTF DOCUMENTATION	3
BFEC/OWU	HELMS, BOBBIE L.	1
BFEC/PAP	LUTZ, RUSSELL L.	1
BFEC/PM	GALE, JOHN P.	1
BFEC/SMG	BATH, HUGH F.	1
BFEC/SMG	ZAMBS, GILES R.	1
JSC/BFEC	OST DOCUMENTATION	2
JSC/DC23	BRANDENBURG, JAMES R.	2
JSC/DE	BARNES, P.	2
JSC/EE7	ROSS, JOHN A.	2
JSC/FS	MAGER, JAMES E.	2
JSC/FS	SEYL, JACK W.	2
JSC/NIPO	MCDONALD, KENNETH D.	1
JSC/ZR-3/SOPCPO	CHASE, WILLIAM R.	2
NASA HQ/T	FORCE, CHARLES T.	1
NASA HQ/TN	COSTRELL, JAMES A.	1
NASA HQ/TN	JIROUSEK, RICHARD S.	1
NASA HQ/TN	TOWNLEY, DAVID L.	1
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